RECOVERING PARENTAL MAGMA COMPOSITIONS: A SINGLE-BLIND TEST OF THE METHOD AND AN ANALYSIS OF A KILAUEAN PARENTAL MAGMA; A. Woronow, A. M. Reid, Dept. Geosciences, U. Houston, Houston, TX 77004; J. H. Jones, JSC, Houston, TX 77058

Introduction:

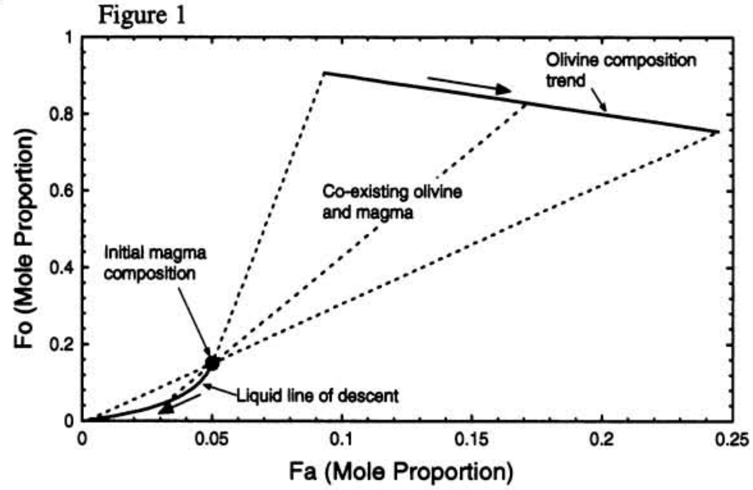
For a parental magma evolving under olivine control—olivine crystallization and segregation—the derivative melts pass through a unique succession of compositions. Because the succession of derivative chemical compositions follows uniquely from the parental-magma composition, model fitting can recover an estimate of the parental-magma composition. We have developed an algorithm to accomplish the model fitting which can treat arbitrary departures from perfect equilibrium crystallization. Previously, [1] used an artificial-intelligence paradigm to fit the model and gave a detailed explanation of the form that the compositional trajectories follow. We have simplified and improved the fitting procedure by using a common method for minimizing an objective function, namely the simplex method; we will refer to this procedure of fitting parental magma compositions as "Derivative-Magma Analysis" (DMA). Here we report a test of DMA (as a single-blind test) on laboratory-synthesized olivine-controlled melt data (5 samples from a single parental composition) and an application to one instance of natural data. For the laboratory-synthesized data, DMA recovered the parental-magma composition essentially within analytical uncertainty. The most difficult oxide to estimate is MgO; the DMA-estimated value deviates from the actual value by less than 1% (oxide weight). For other oxides, predictions differ, typically, by less than ½% from actual values. DMA also reliably estimates compositions of olivines that coexisted with each derivative melt.

The natural system examined with DMA is the summit eruption of Kilauea in 1959. We estimate Mg# = 73 (MgO ~ 16% by weight) for the parental magma. This estimated MgO content is significantly higher than some estimates by previous authors who favored low-Mg parental magmas that are once-removed from their mantle sources.

Olivine Control by Accumulation:

A less interesting class of olivine control occurs when whole-rock samples contain varying volumes of cumulate olivine; this is a mechanical-mixing effect not indicative of a liquid line of descent. Figure 1 depicts a trajectory for a melt evolving under olivine control (lower left). Tie lines join coexisting melt and olivine compositions. Mechanical mixtures involving varying amounts of melt and crystals would scatter whole-rock analyses along a tie line; such a suite of samples does not describe a liquid line of descent, and, if mistaken for one, would lead to an erroneous estimate of the composition of the parental magma. We avoid this possible pitfall by rejecting whole-rock analyses and using only glass analyses.

Figure 1



A Single-Blind Test:

One author (AMR) provided another (AW) with five chemical analyses from experimental runs on a single starting composition. The analyses were of quench glasses whose liquids coexisted with olivines as the only solid phase. Neither the composition of the parental magma, nor the abundances, nor compositions of the coexisting olivines were relayed along with the glass analyses. Table 1 gives the parental composition estimated by DMA. The estimated composition is in good agreement with the actual parental composition. Furthermore, estimates of the compositions of olivines that should coexist with each of the glasses were also generated, and closely matched averaged microprobe analyses.

Parental Magmas: Woronow A. *et al.*

Table 1: Results of the single-blind test

	Parental Magma Oxide-Weight Proportions								
	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
DMA Est.	**0.510**	**0.034**	**0.108**	**0.113**	**0.001**	**0.114**	**0.086**	**0.022**	**0.011**
Actual	0.510	0.033	0.107	0.115	0.002	0.108	0.086	0.023	0.011

Kilauean Summit Eruption, 1959:

Disagreements exist over the initial MgO content of the source magma for Kilauean eruptions. The opinions can be categorized roughly as those favoring *Low* MgO (6-12%): [2]; *Intermediate* MgO (12-15%): [3,4,5,6]; *High* MgO (13-20%): [7]; and *Very High* MgO (20-25%): [8].

Chemical analyses of products from the 1959-60 Kilauea eruptions were reported in [2]. Some analyses represented whole-rock specimens that commonly exhibit cumulate olivine and thus are not useful for DMA. However, two suites of samples of glasses were collected. One set, from flank eruptions, is unsuitable for this analysis because it apparently involved multiple melts ([2] p. A15), but the samples from the 1959 summit eruption, according to the evidence presented by [2], seem ideal for DMA. Unfortunately, there are but three samples (S5g, S7g, and S11g).

Murata and Richter [2] suggested that the most primitive glass, S5g, is the best estimate of the primitive melt while Wilkinson [4] suggested a parental magma with 13-14% MgO (his Table 3, entry 7). DMA suggests a more MgO rich parental magma than either of these (Table 2). Figure 2 shows the olivine-fractionation trends that each of these suggested parental, or primitive, magmas implies. The parental magma suggested by DMA provides a superior fit to the three data points.

Figure 2

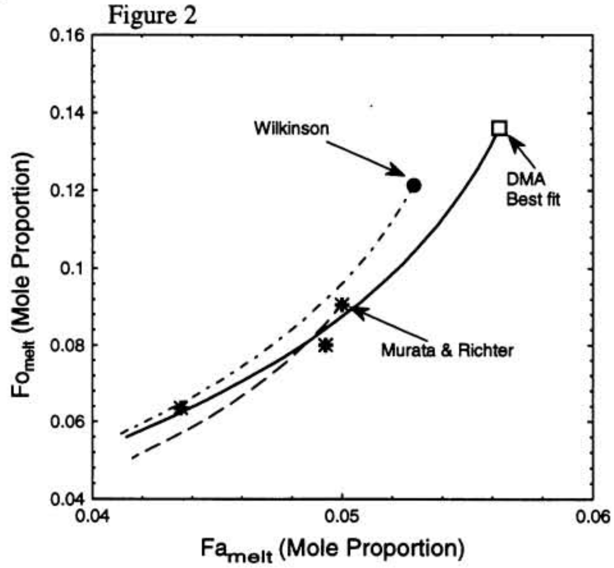


Table 2: Estimates of Kilauean parental-magma compositions

	Estimated Parental Magma Oxide Weight Proportions										Est.
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Mg#
DMA	**0.474**	**0.022**	**0.107**	**0.015**	**0.106**	**0.001**	**0.158**	**0.092**	**0.018**	**0.004**	**73**
S5g	0.491	0.025	0.125	0.016	0.101	0.002	0.102	0.111	0.020	0.005	64
Wilkinson	0.490	0.021	0.119	0.021	0.101	0.002	0.130	0.097	0.020	0.004	70

References: [1] Woronow, A., Reid, A.M., Jones, J.H., and Pingitore, N.E., Jr., (1994) *Abst. LPSC.* XXV, 1513-1514. [2] Murata, K.J. and Richter, D.H. (1966) *US Geol. Surv. Prof. Paper 537-A.* [3] Macdonald, G.A. and Katsura, T. (1961) *Pacific Sci.*, **15**, 358-69. [4]Wilkinson, J.F.G. (1991) *J. Petrology*, **32**, 863-907. [5]Wilkinson, J.F.G. and Hensel, H.D. (1988) *Contrib. Mineral. Petrol.* [6] Wright, T.L. (1971) *US GS Prof. Paper 735.* [7] Maaløe, S. (1979) *Lithos*, **12**, 59-72. [8] Murata, K.J. (1970) *Naturwissenschaft*, **57**, 108-113.